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Shirafuji

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(54) **IMAGE FORMING APPARATUS INCLUDING CORRECTION UNIT THAT CORRECTS TONE CORRECTION TABLE**

(71) Applicant: **CANON KABUSHIKI KAISHA**, Tokyo (JP)

(72) Inventor: **Yasuhito Shirafuji**, Kashiwa (JP)

(73) Assignee: **CANON KABUSHIKI KAISHA**, Tokyo (JP)

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(51) **Int. Cl.**
G03G 15/00 (2006.01)

(52) **U.S. Cl.**
CPC .. ***G03G 15/5041*** (2013.01); *G03G 2215/0129* (2013.01); *G03G 2215/0164* (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/55; G03G 15/556
See application file for complete search history.

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Primary Examiner — Erika J Villaluna
(74) *Attorney, Agent, or Firm* — Fitzpatrick, Cella, Harper & Scinto

(57) **ABSTRACT**

An image forming apparatus includes: a forming unit configured to form an image on an image carrier; a holding unit configured to hold a reference table and a tone correction table that convert a plurality of input image data values into corresponding output image data values; and a correcting unit configured to control the forming unit to form a first test pattern including a plurality of images having different densities on the image carrier using the tone correction table, and correct the tone correction table by detecting densities of the plurality of images. The correcting unit is further configured to correct the tone correction table by updating the tone correction table using the detected densities of the plurality of images and then interpolating the updated tone correction table using the reference table.

9 Claims, 8 Drawing Sheets

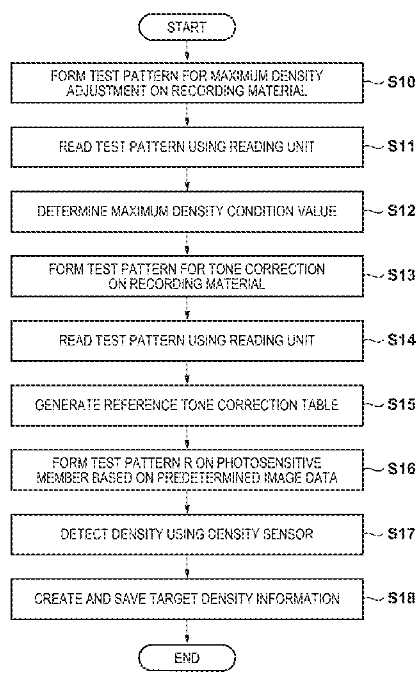

FIG. 1

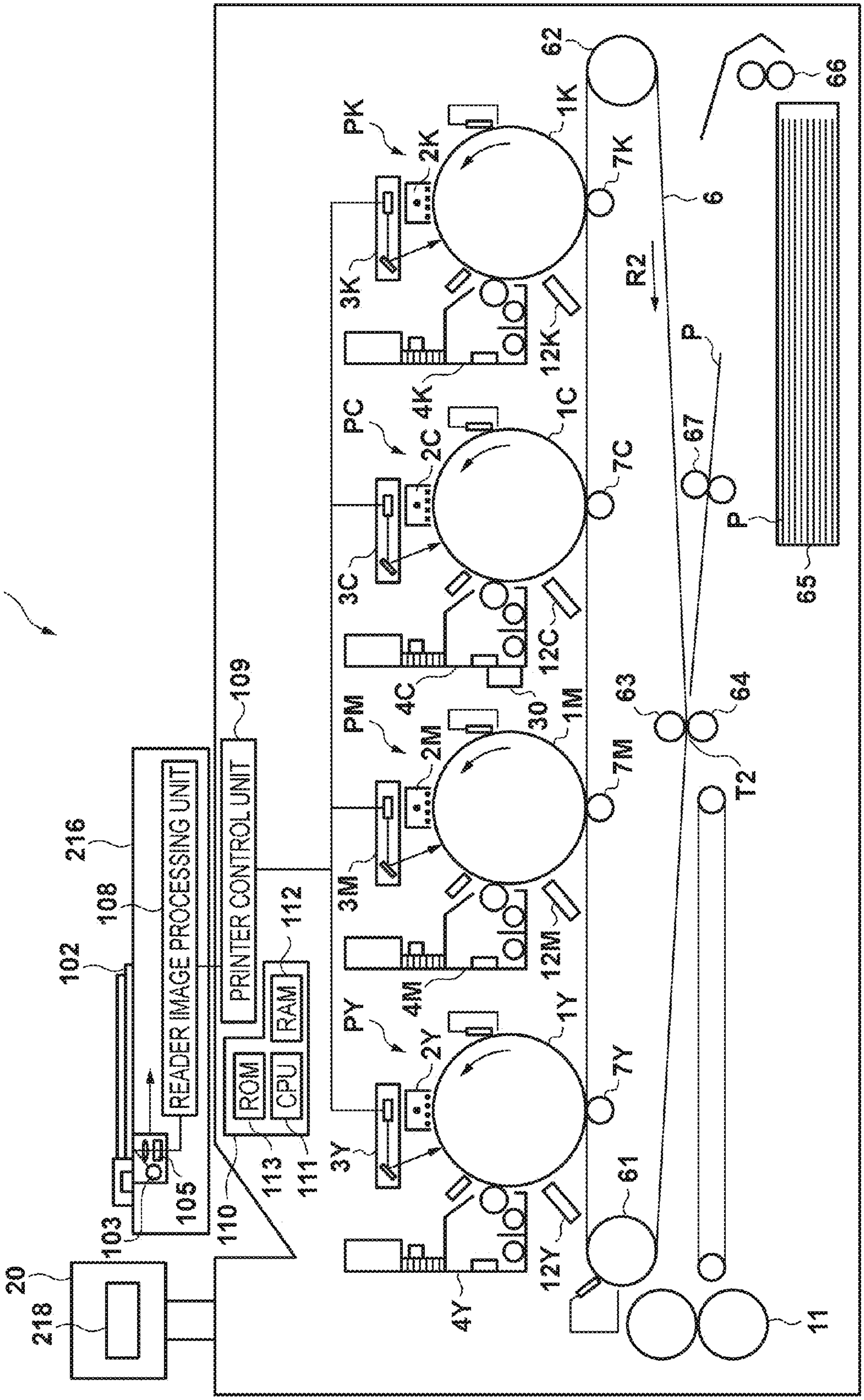
100
READER IMAGE PROCESSING UNIT
PRINTER CONTROL UNIT
ROM
RAM
CPU
20
218
216
102
103
105
108
109
110
111
112
113
PY
PM
PC
PK
1Y
1M
1C
1K
2Y
2M
2C
2K
3Y
3M
3C
3K
4Y
4M
4C
4K
7Y
7M
7C
7K
12Y
12M
12C
12K
30
6
R2
P
P
11
61
62
63
64
65
66
67
T2

FIG. 2A

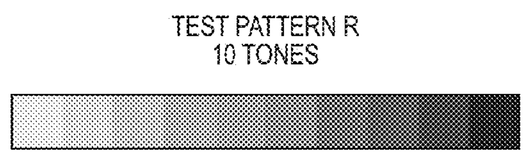
TEST PATTERN R
10 TONES

FIG. 2B

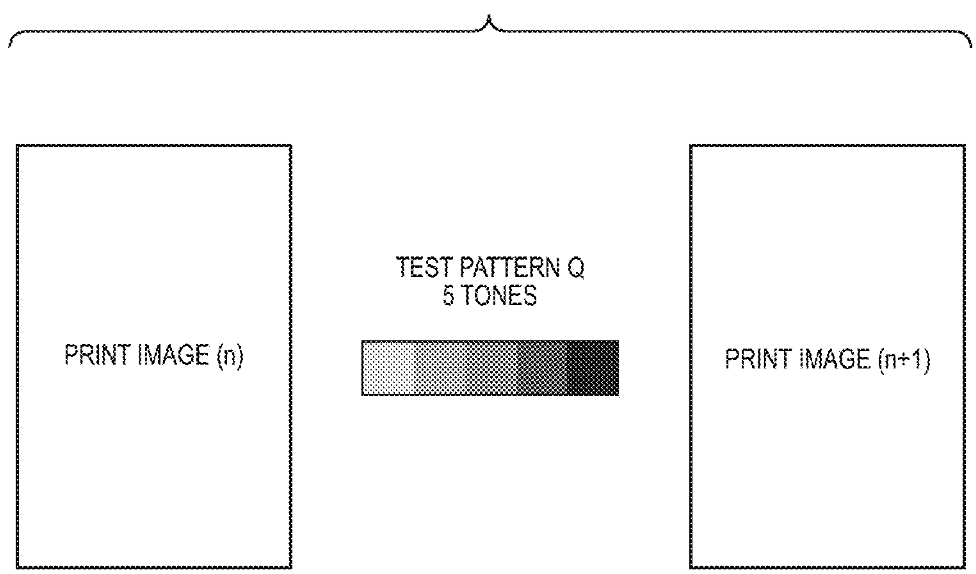
PRINT IMAGE (n)
TEST PATTERN Q
5 TONES
PRINT IMAGE (n+1)

FIG. 3

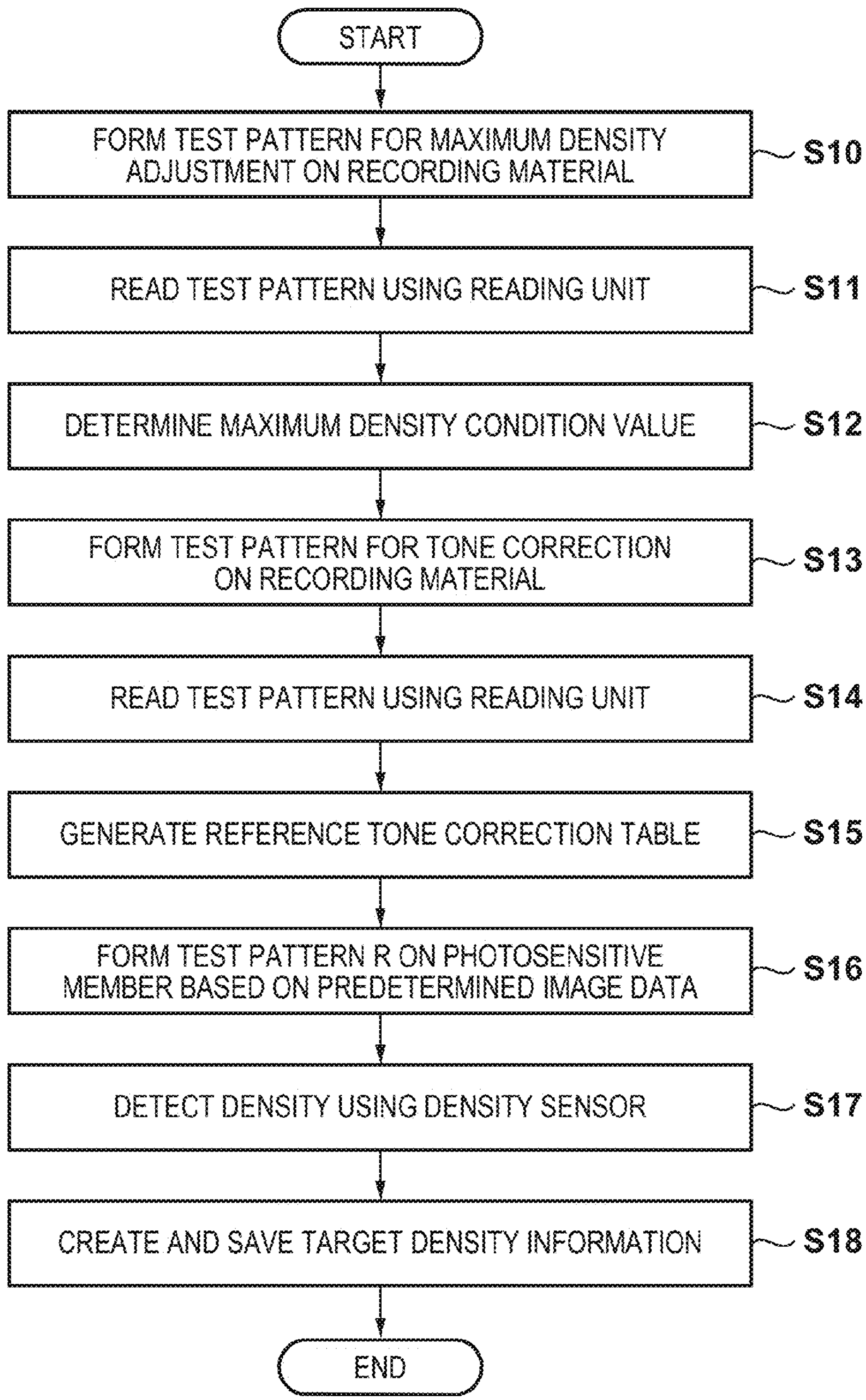
START
FORM TEST PATTERN FOR MAXIMUM DENSITY ADJUSTMENT ON RECORDING MATERIAL
S10
READ TEST PATTERN USING READING UNIT
S11
DETERMINE MAXIMUM DENSITY CONDITION VALUE
S12
FORM TEST PATTERN FOR TONE CORRECTION ON RECORDING MATERIAL
S13
READ TEST PATTERN USING READING UNIT
S14
GENERATE REFERENCE TONE CORRECTION TABLE
S15
FORM TEST PATTERN R ON PHOTOSENSITIVE MEMBER BASED ON PREDETERMINED IMAGE DATA
S16
DETECT DENSITY USING DENSITY SENSOR
S17
CREATE AND SAVE TARGET DENSITY INFORMATION
S18
END

FIG. 4A

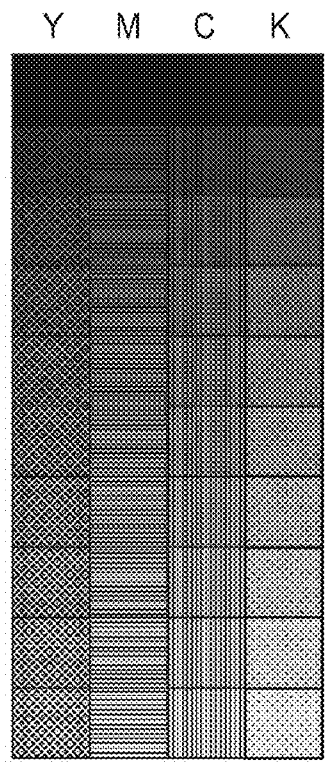

FIG. 4B

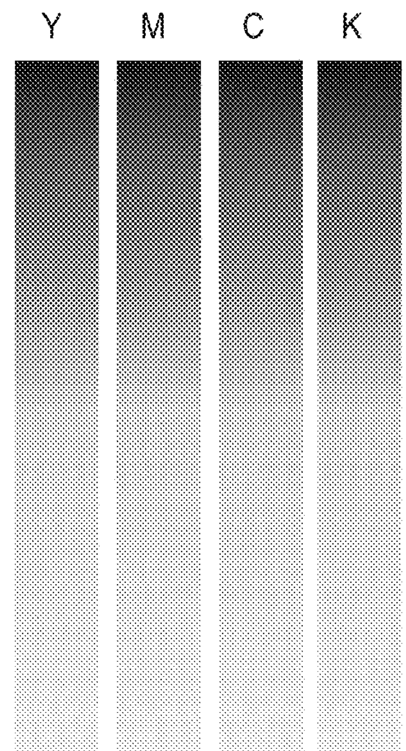

FIG. 5

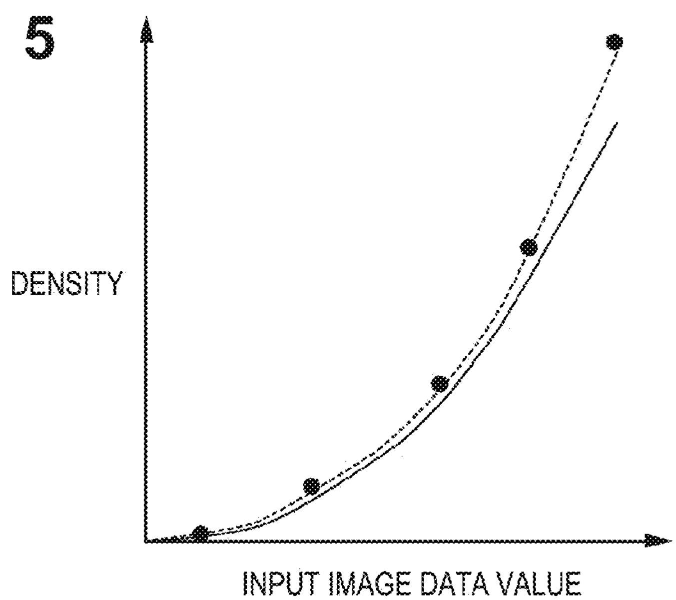

FIG. 6

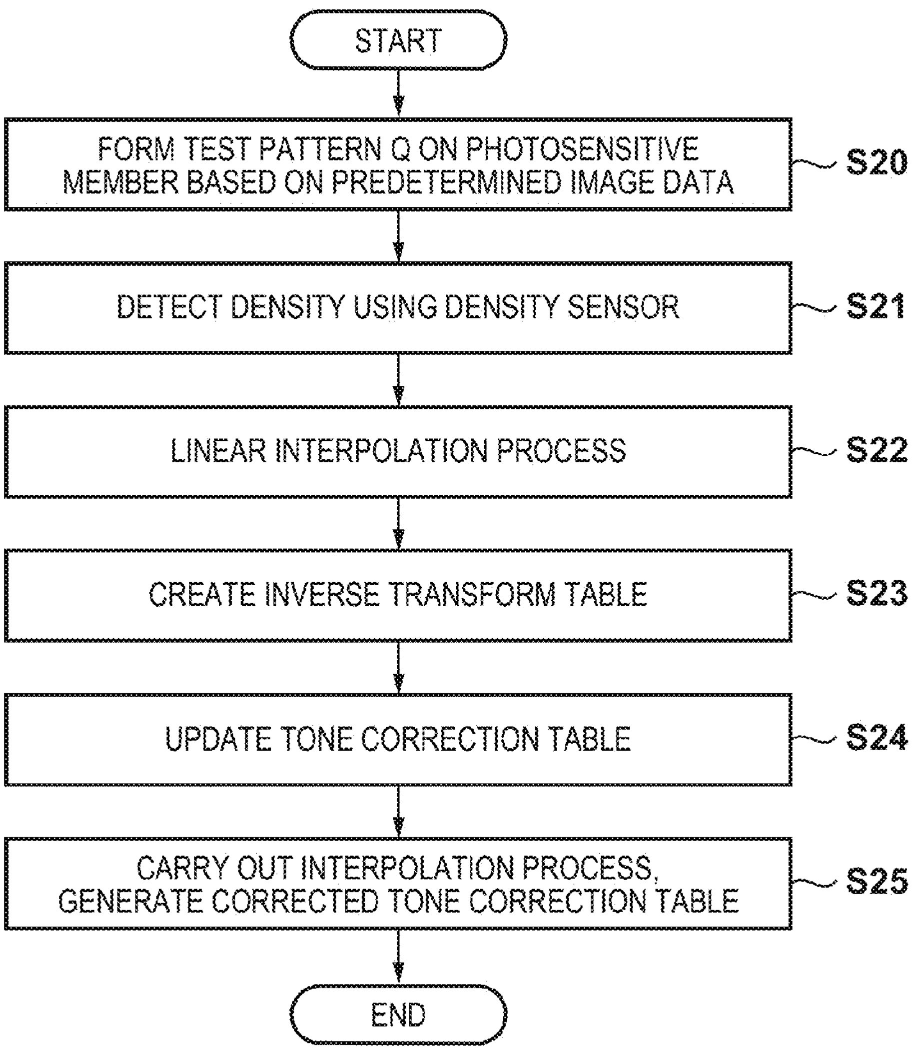
START
FORM TEST PATTERN Q ON PHOTOSENSITIVE MEMBER BASED ON PREDETERMINED IMAGE DATA
S20
DETECT DENSITY USING DENSITY SENSOR
S21
LINEAR INTERPOLATION PROCESS
S22
CREATE INVERSE TRANSFORM TABLE
S23
UPDATE TONE CORRECTION TABLE
S24
CARRY OUT INTERPOLATION PROCESS, GENERATE CORRECTED TONE CORRECTION TABLE
S25
END

FIG. 7

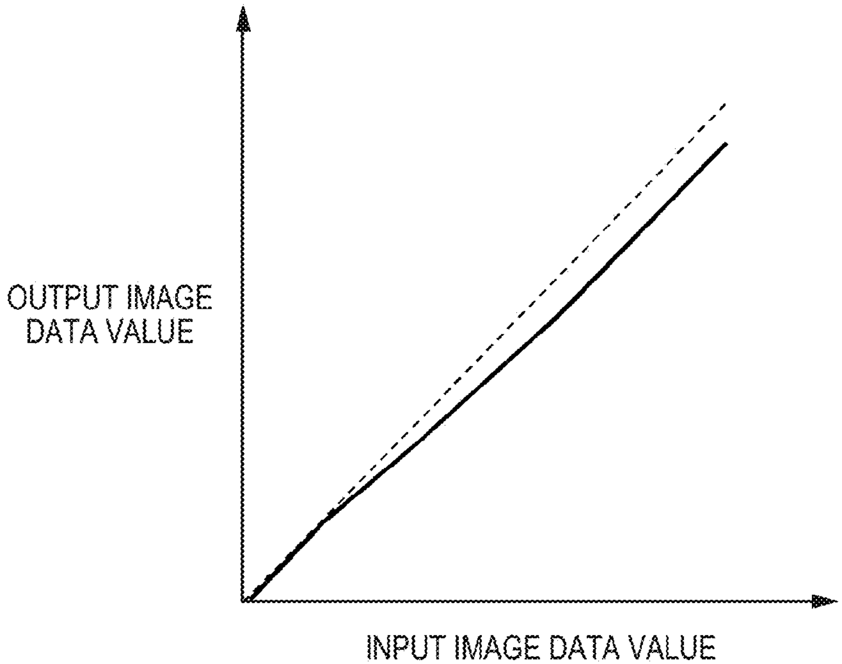
OUTPUT IMAGE DATA VALUE
INPUT IMAGE DATA VALUE

FIG. 8

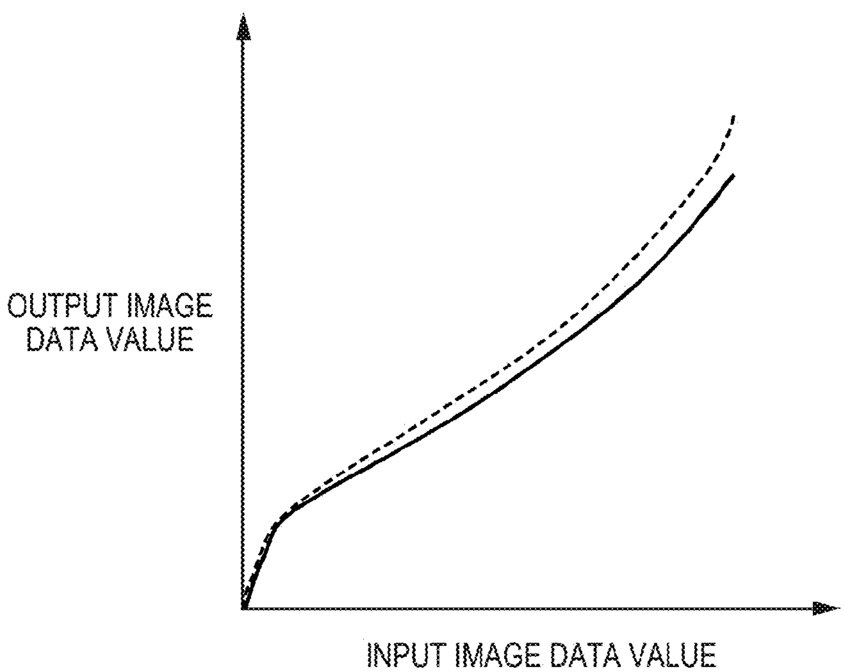
OUTPUT IMAGE DATA VALUE
INPUT IMAGE DATA VALUE

FIG. 9A

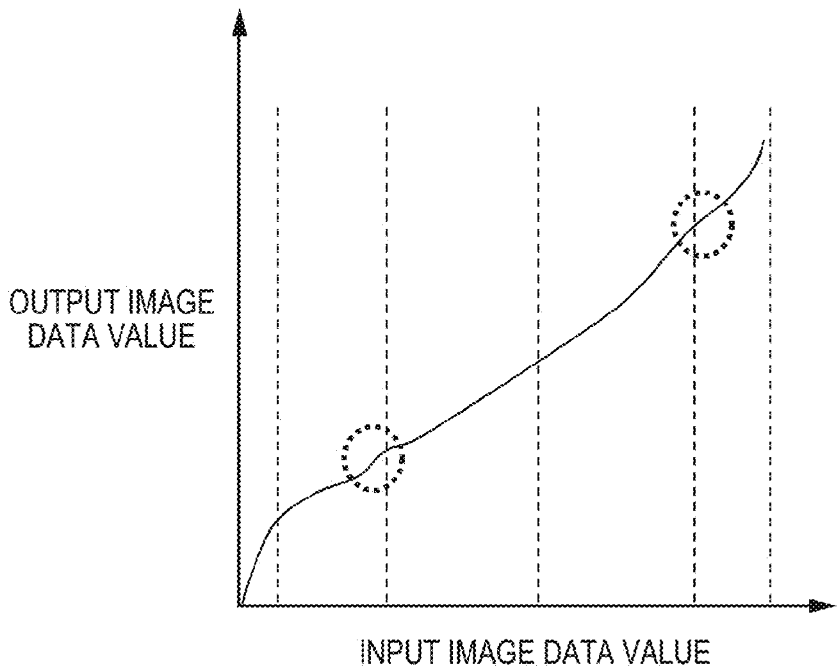
OUTPUT IMAGE
DATA VALUE
INPUT IMAGE DATA VALUE

FIG. 9B

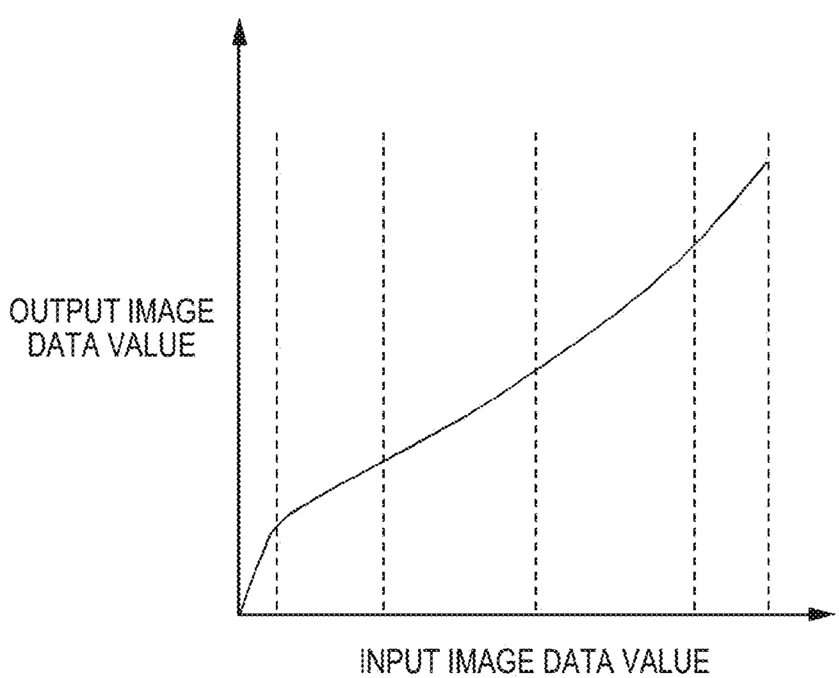
OUTPUT IMAGE
DATA VALUE
INPUT IMAGE DATA VALUE

FIG. 10A

15
45
105
165
225

FIG. 10B

30
75
135
195
255

IMAGE FORMING APPARATUS INCLUDING CORRECTION UNIT THAT CORRECTS TONE CORRECTION TABLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present disclosure relates to density control techniques in image forming apparatuses.

2. Description of the Related Art

Image forming apparatuses that use electrophotographic systems require stable densities and tones in output images. To that end, U.S. Pat. No. 5,752,126 and U.S. Pat. No. 5,583,644 disclose configurations that stabilize the quality of an image by forming a test pattern on an image carrier and adjust image forming conditions, generate a tone correction table, and so on by reading the density of the formed test pattern using a sensor.

When creating a tone correction table, correction values for densities not formed by the test pattern are obtained by interpolating results of measuring the densities formed by the test pattern. However, pixel values in the image data provided to the image forming apparatus and the densities actually formed by those pixel values are not in a linear relationship, and error appears particularly in low-density and high-density regions where the degree of non-linearity is more marked. Although increasing the number of densities formed by the test pattern is conceivable as a way to solve this problem, doing so increases the time required for tone control and drastically reduces productivity.

SUMMARY OF THE INVENTION

According to an aspect of the present invention, an image forming apparatus includes: a forming unit configured to form an image on an image carrier; a holding unit configured to hold a reference table and a tone correction table that convert a plurality of input image data values into corresponding output image data values; and a correcting unit configured to control the forming unit to form a first test pattern including a plurality of images having different densities on the image carrier using the tone correction table, and correct the tone correction table by detecting densities of the plurality of images. The correcting unit is further configured to correct the tone correction table by updating the tone correction table using the detected densities of the plurality of images and then interpolating the updated tone correction table using the reference table.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram illustrating an image forming apparatus according to an embodiment.

FIGS. **2**A and **2**B are diagrams illustrating a test pattern according to an embodiment.

FIG. **3** is a flowchart illustrating tone correction control according to an embodiment.

FIGS. **4**A and **4**B are diagrams illustrating a toner image formed in tone correction control according to an embodiment.

FIG. **5** is a diagram illustrating a target density and the density of a test pattern detected in correction control according to an embodiment.

FIG. **6** is a flowchart illustrating correction control according to an embodiment.

FIG. **7** is a diagram illustrating a graph corresponding to an inverse transform table according to an embodiment.

FIG. **8** is a diagram illustrating a tone correction table according to an embodiment.

FIGS. **9**A and **9**B are diagrams illustrating a tone correction table and a post-interpolation tone correction table according to an embodiment.

FIGS. **10**A and **10**B are diagrams illustrating combinations of image data used in test patterns according to an embodiment.

DESCRIPTION OF THE EMBODIMENTS

Hereinafter, exemplary embodiments of the present invention will be described with reference to the drawings. Note that the following embodiments are to be taken as examples only, and the scope of the present invention is not intended to be limited to the embodiments. Note also that constituent elements not necessary for the descriptions of the embodiments have been omitted from the drawings.

First Embodiment

FIG. **1** is a schematic diagram illustrating an image forming apparatus **100** according to the present embodiment. In the image forming apparatus **100** shown in FIG. **1**, yellow, magenta, cyan, and black image forming sections PY, PM, PC, and PK are arranged along an intermediate transfer belt **6**. A photosensitive member **1**Y of the image forming section PY, which serves as an image carrier, is rotationally driven in the direction of the arrow shown in FIG. **1**, and is charged to a predetermined potential by a charging unit **2**Y. An exposure unit **3**Y forms an electrostatic latent image on the surface of the photosensitive member **1**Y by scanning and exposing the photosensitive member **1**Y with light. A developing unit **4**Y visualizes the electrostatic latent image on the photosensitive member **1**Y as a toner image by outputting a developing bias and supplying yellow toner (coloring material) to the electrostatic latent image. A primary transfer roller **7**Y outputs a primary transfer bias and transfers the toner image formed on the photosensitive member **1**Y to the intermediate transfer belt **6** serving as an image carrier. The image forming section PY also includes a density sensor **12**Y for detecting the density of the toner image formed on the photosensitive member **1**Y. The density sensor **12**Y emits light onto the photosensitive member **1**Y and detects the density based on light reflected thereby, for example.

Aside from the color of the toner used, the image forming sections PM, PC, and PK have the same configuration as the image forming section PY, and thus descriptions of the image forming sections PM, PC, and PK will be omitted here. Note also that in the following descriptions, reference numerals without the letters Y, M, C, and K appended thereto will be used in cases where it is not necessary to distinguish between different colors. A multicolor toner image is formed on the intermediate transfer belt **6** by transferring the toner images formed on the photosensitive members **1** of the respective image forming sections onto the intermediate transfer belt **6** in a superimposed manner.

The intermediate transfer belt **6** is wrapped upon three rollers **61**, **62**, and **63**, and is rotationally driven in the direction of R2 indicated in FIG. **1**. A recording material P, which is an image carrier extracted from a cassette **65**, is conveyed, by roller pairs **66** and **67**, toward a secondary transfer portion T**2** configured of the roller **63** and a secondary transfer roller **64**. The toner image transferred onto the intermediate transfer belt **6** is then transferred onto the recording material P at the secondary transfer portion T**2**. The recording material P is then heated and compressed by a fixing unit **11**, the toner image is fixed, and the recording material P is discharged to the exterior of the apparatus.

A light source **103** of a reading unit **216** emits light onto a recording material placed on a platen **102**, and a CCD sensor **105** reads an image of the recording material by receiving the light reflected therefrom. Image data read by the CCD sensor **105** undergoes predetermined image processing in a reader image processing unit **108** and a printer control unit **109**. Note that the image forming apparatus **100** according to the present embodiment is configured to be capable of printing image data received over a telephone line (fax), image data received from a computer over a network, and so on, in addition to images read by the reading unit **216**. Meanwhile, an operating unit **20** enables a user to operate the image forming apparatus **100**, and includes a display unit **218** for displaying the status of the image forming apparatus **100** to the user. A control unit **110** performs overall control of image forming operations carried out by the image forming apparatus **100**, and includes a CPU **111**, a RAM **112**, and a ROM **113**. The control unit **110** determines and obtains density information of the toner image formed on the photosensitive member **1** based on a signal from the density sensor **12**. The CPU **111** controls the image forming apparatus **100** using programs and various types of data held in the ROM **113**, employing the RAM **112** as a work area. Furthermore, the image forming apparatus **100** includes an environment sensor **30** that obtains information of the environment in which the image forming apparatus is located, such as temperature, humidity, or both, and communicates this information to the control unit **110**.

Next, tone correction control according to the present embodiment will be described. Note that the tone correction control is carried out for each color. In the present embodiment, the tone correction control is performed in response to a user operation or to a predetermined condition being met. In the tone correction control, the toner image formed on and fixed onto the recording material, the fixed toner image is read by the reading unit **216**, and image forming conditions related to density are determined. In this density control, an image forming condition value for forming an image at a maximum density serving as a target (referred to as a "target maximum density" hereinafter; the condition value will be referred to as a "maximum density condition value"), and a tone correction table for converting the values of input image data in order to realize the target density, are created. Using the created tone correction table, a test pattern R is furthermore formed on the photosensitive member **1** using the maximum density condition value that has been determined. In the present embodiment, the test pattern R is a pattern including images of ten types of different densities (tones), including a solid-color area (maximum density area), as shown in FIG. **2**A. The image forming apparatus **100** measures the densities in the test pattern R using the density sensor **12** and obtains target density information expressing a relationship between the input values of the image data used to form the test pattern R and the densities formed on the photosensitive member **1** using those input values.

Then, when sequentially forming images, the image forming apparatus **100** executes correction control using the tone correction table (called simply "correction control" hereinafter) each time a predetermined number of sheets passes through. In the correction control, a test pattern Q, which has a lower number of densities than the test pattern R formed in the tone correction control, is formed on the photosensitive member **1**, as shown in FIG. **2**B; the densities in the test pattern Q are then detected by the density sensor **12**. In the present embodiment, the test pattern Q is a pattern including images of five types of different densities (tones), including a solid-color area (maximum density area). Note that in the correction control, the test pattern Q is formed in a region on the photosensitive member **1** between toner images to be printed, as shown in FIG. **2**B.

First, details of the tone correction control will be described using FIG. **3**. In S**10**, the control unit **110** forms a test pattern on the recording material using image data of a value expressing a maximum density. FIG. **4**A illustrates an example of the test pattern formed in S**10**. In the case where the image data is 8-bit data, for example, the test pattern shown in FIG. **4**A takes a value of 255, which expresses the maximum density, as the stated maximum density value, and is formed while varying an image forming condition regarding the density. Although the following descriptions assume that an exposure amount is used as the image forming condition varied for the density control, the configuration may be such that other image forming conditions regarding the density are used, such as other values that vary the developing contrast, namely the developing bias, a charging bias, and the like. A configuration that varies multiple image forming conditions related to density may also be employed. A user sets the recording material on which the test pattern has been formed in the reading unit **216**, and in S**11**, the control unit **110** detects the densities in the test pattern by causing the reading unit **216** to read the test pattern. In S**12**, based on the detected densities, the control unit **110** determines the maximum density condition value, or in other words, a value of the image forming condition at which the toner image formed using the image data expressing the maximum density as input values reaches the target maximum density. Note that the image forming condition is the exposure amount in this example, as described above.

Next, in S**13**, the control unit **110** forms a test pattern for tone correction on the recording material. FIG. **4**B illustrates an example of the test pattern formed in S**13**. In the case where the image data is 8-bit data, for example, the test pattern shown in FIG. **4**B is formed using multiple values selected from 0 to 255, such as 64 values. The user sets the recording material on which the test pattern has been formed in the reading unit **216**, and in S**14**, the control unit **110** detects the densities of the test pattern by causing the reading unit **216** to read the test pattern. In S**15**, the control unit **110** generates a reference tone correction table (reference table) based on the detected densities and saves the generated table in the RAM **112**. Then, in S**16**, the control unit **110** forms the test pattern R shown in FIG. **2**B on the photosensitive member **1** using the reference tone correction table, and uses the density sensor **12** to detect the densities thereof in S**17**. The control unit **110** then generates the target density information, which expresses a relationship between the image data values used in S**16** and the densities in the test pattern detected in S**17**, and saves the generated information in the RAM **112** in S**18**. A solid line in FIG. **5** indicates the target density information saved in S**18**.

Next, correction control according to the present embodiment will be described using FIG. **6**. Note that the first time the correction control is carried out after the tone correction control has been performed, the tone correction table to be corrected is the reference tone correction table, whereas in subsequent instances of the correction control, the tone correction table corrected through the previous correction control is the subject of the correction. However, the control unit **110** continues to hold the reference tone correction table in the RAM **112** even after the correction control has been performed. In other words, two tables, namely the reference tone correction table and the tone correction table corrected through the correction control, are held in the RAM **112** after the correction control has been executed. After the tone correction control has been executed, the control unit **110** forms images using the reference tone correction table until the correction control is carried out for the first time, and then forms images using the corrected tone correction table after the correction control has been executed.

Note that the correction control is performed each time a predetermined number of sheets passes through when sequentially forming images, as mentioned above. When the correction control starts, in S**20**, the control unit **110** forms the test pattern Q shown in FIG. **2**B on the photosensitive member **1**. Note that the number of images of different densities contained in the test pattern Q, which in this example is five, is less than the number of images of different densities contained in the test pattern shown in FIG. **4**B and used to generate the reference tone correction table, the test pattern shown in FIG. **2**A formed in order to obtain the target density information, and so on. In S**21**, the control unit **110** detects the densities in the test pattern Q using the density sensor **12**, and linearly interpolates the detection results in S**22**. The black circles in FIG. **5** are obtained by plotting the image data values of the five densities in the test pattern Q against the respective detected densities, and the dotted line curve indicates the result of the linear interpolation. Next, in S**23**, the control unit **110** creates an inverse transform table by carrying out an inverse transform on the detection result indicated by the dotted line using the target density information, indicated by a solid line. FIG. **7** illustrates input image data values and output image data values indicated in the inverse transform table as a graph. The dotted line in FIG. **7** indicates the inverse transform table in the case where the detection results obtained in S**22** match the target density information, with the input image data values and output image data values having the same corresponding values. On the other hand, the solid line in FIG. **7** indicates an example of the inverse transform table in the case where the detection results obtained in S**22** are denser than the target density expressed by the target density information, as shown in FIG. **5**. The input image data values have been converted to lower values in the solid line in FIG. **7** in order to bring the obtained density closer to the target density.

In S**24**, the control unit **110** updates the tone correction table using the tone correction table to be corrected, held in the RAM **112**, and the inverse transform table created in S**23**. As described above, the tone correction table to be corrected is the reference tone correction table generated through the tone correction control in the case where the correction control has not been performed even once, and is the tone correction table corrected in the previous correction control in the case where the correction control has been performed once or more. The dotted line in FIG. **8** is a graph of the pre-update tone correction table, and the solid line in FIG. **8** is a graph of the updated tone correction table in the case where the inverse transform table is as indicated by the solid line in FIG. **7**. The updated tone correction table is obtained, for example, by dividing an output image data value in the inverse transform table shown in FIG. **7** by the corresponding input image data value, and multiplying the corresponding value in the pre-update tone correction table by the value obtained through the stated division. For example, subsequent image forming can also be carried out using the tone correction table updated in S**24**. However, in the present embodiment, the test pattern Q formed in S**20** has a lower number of tones than the test pattern, shown in FIG. **4**A, that is used to generate the reference tone correction table. As such, an interpolation process is carried out for the updated tone correction table in S**25**. This is done because the values found through the linear interpolation carried out in S**22** are skewed from the actual characteristics. The interpolation process carried out in S**25** will be described in detail below.

First, the following descriptions assume that the image data is 8-bit data for each pixel, or in other words, that each pixel takes on a value from 0 to 255. Y_i (where i is an integer from 0 to 255) is taken as an output image data value that corresponds to the input image data value i in the tone correction table updated in S**24**. Furthermore, YR_i is taken as an output image data value that corresponds to the input image data value i in the reference tone correction table. Further still, the five input values for the image data used to form the test pattern Q are represented by p1, p2, p3, p4, and p5. Note that p1<p2<p3<p4<p5.

The control unit **110** finds the output image data values in the interpolated tone correction table corresponding to the input image data values i through the following formulae.

when $0 \le i \le p1$

$$(Y_{p1}-0)/(YR_{p1}-0)\times(YR_i-0)+0$$

when $p1 \le i \le p2$

$$(Y_{p2}-Y_{p1})/(YR_{p2}-YR_{p1})\times(YR_i-YR_{p1})+Y_{p1}$$

when $p2 \le i \le p3$

$$(Y_{p3}-Y_{p2})/(YR_{p3}-YR_{p2})\times(YR_i-YR_{p2})+Y_{p2}$$

when $p3 \le i \le p4$

$$(Y_{p4}-Y_{p3})/(YR_{p4}-YR_{p3})\times(YR_i-YR_{p3})+Y_{p3}$$

when $p4 \le i \le p5$

$$(Y_{p5}-Y_{p4})/(YR_{p5}-YR_{p4})\times(YR_i-YR_{p4})+Y_{p4}$$

In the corrected tone correction table found through the aforementioned formulae, the output image data values corresponding to the input values used to form the test pattern Q are the same as the output image data values in the tone correction table updated using the results of detecting the test pattern Q. The output image data value corresponding to an input value between two adjacent input values among the input values used to form the test pattern Q is interpolated according to the reference tone correction table.

The control unit **110** saves the tone correction table created through the interpolation process performed in S**25** in the RAM **112**, and uses that table in subsequent image forming processes. Note that the values used in the updated tone correction table in the aforementioned formulae are Y_{pi} only. Accordingly, the configuration may be such that the linear interpolation process of S**22** is not provided, and the output image data values of the tone correction table to be corrected that correspond to the input values used to form the test pattern Q are updated using the results of detecting the test pattern Q, and are then interpolated using the reference tone correction table. Regardless of what configuration is employed, the graph of the output image data values corresponding to the input image data values p(k−1) to pk (where k is 1 to 5) in the interpolated tone correction table is based on the form of the reference tone correction table, and thus the values thereof are based on the values of the tone correction table updated based on the detection results.

FIG. **9**A is a graph expressing the tone correction table updated in S**24** of FIG. **6** after 10,000 sheets of paper have passed through in succession, and FIG. **9**B is a graph illustrating a tone correction table interpolated in S**25** of FIG. **6**. Compared to FIG. **9**B, there is an area in FIG. **9**A where the slope of the graph changes drastically (the area enclosed by the dotted line). Furthermore, tone collapse, pseudo-borders, and so on appear in images formed using the tone correction table shown in FIG. **9**A. On the other hand, such tone collapse, pseudo-borders, and so on do not appear in images formed using the interpolated tone correction table shown in FIG. **9**B. Accordingly, using the reference tone correction table to carry out an interpolation process on the tone correction table created using a test pattern with few densities makes it possible to carry out tone correction control accurately.

Although the reference tone correction table is formed by reading a test pattern fixed onto a recording material in the present embodiment, the table may instead be formed by using a sensor to detect the test pattern formed on the intermediate transfer belt **6**, the photosensitive member **1**, or the like, for example. Regardless of which configuration is used, interpolation is carried out in the correction control using the reference tone correction table in the present embodiment, which makes it possible to accurately correct the tone correction table using a test pattern with a low number of images.

Second Embodiment

In the first embodiment, the densities used in the test pattern Q are fixed, but in the present embodiment, the densities are varied with each instance of correction control. For example, FIG. **10**A illustrates a first combination of five densities used in the test pattern Q, whereas FIG. **10**B illustrates a second combination. These two combinations are used in an alternating manner each time the correction control is performed, for example. As a result, a greater number of types of densities are formed than in the first embodiment, which in turn makes it possible to increase the accuracy of control. Note that rather than two combinations as shown in FIGS. **10**A and **10**B, the configuration may be such that any desired number of three or more combinations may be switched in order and used.

Third Embodiment

In the first embodiment, the respective detected densities in the test pattern Q measured in S**22** of FIG. **6** are linearly interpolated. In the present embodiment, a reference correction table is used in the interpolation of the respective detected densities in the test pattern Q in S**22** of FIG. **6**. The interpolation process using the reference tone correction table carried out in S**22** uses the same calculation formulae, aside from Y_i in the first embodiment being replaced with the image data values corresponding to the detected densities of FIG. **5**.

Other Embodiments

Embodiments of the present invention can also be realized by a computer of a system or apparatus that reads out and executes computer executable instructions (e. g., one or more programs) recorded on a storage medium (which may also be referred to more fully as a 'non-transitory computer-readable storage medium') to perform the functions of one or more of the above-described embodiments and/or that includes one or more circuits (e. g., application specific integrated circuit (ASIC)) for performing the functions of one or more of the above-described embodiments, and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiments and/or controlling the one or more circuits to perform the functions of one or more of the above-described embodiments. The computer may comprise one or more processors (e. g., central processing unit (CPU), micro processing unit (MPU)) and may include a network of separate computers or separate processors to read out and execute the computer executable instructions. The computer executable instructions may be provided to the computer, for example, from a network or the storage medium. The storage medium may include, for example, one or more of a hard disk, a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)™), a flash memory device, a memory card, and the like.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2013-261839, filed on Dec. 18, 2013, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. An image forming apparatus comprising:

a forming unit configured to form an image on an image carrier;

a holding unit configured to hold a reference table and a tone correction table that convert a plurality of input image data values into corresponding output image data values; and

a correcting unit configured to control the forming unit to form a first test pattern including a plurality of images having different densities on the image carrier using the tone correction table, and correct the tone correction table by detecting densities of the plurality of images,

wherein the correcting unit is further configured to correct the tone correction table by updating the tone correction table using the detected densities of the plurality of images and then interpolating the updated tone correction table using the reference table,

wherein the reference table is generated using a second test pattern including a plurality of images having different densities, and a number of the images having different densities included in the second test pattern is greater than a number of the images having different densities included in the first test pattern.

2. The image forming apparatus according to claim **1**, wherein the correcting unit is further configured to update the tone correction table by comparing the detected densities of the plurality of images with target densities for the input image data values used to form the plurality of images.

3. The image forming apparatus according to claim **2**, wherein the target densities are obtained when generating the reference table, by detecting densities of a plurality of images formed on the image carrier as a result of converting a plurality of different input image data values using the generated reference table.

4. The image forming apparatus according to claim **1**, wherein the correcting unit is further configured to update the tone correction table by linearly interpolating the detected densities of the plurality of images and then comparing the densities of input image data values obtained through the interpolation with target densities for the input image data values.

5. The image forming apparatus according to claim **1**, wherein the correcting unit is further configured to update the tone correction table by interpolating the detected densities of the plurality of images using the reference table and then comparing the densities of input image data values obtained through the interpolation with target densities for the input image data values.

6. The image forming apparatus according to claim **1**, wherein the correcting unit includes a plurality of combinations of the plurality of images having different densities formed as the first test pattern, and is further configured to form the first test pattern by selecting a single combination from the plurality of combinations when correcting the tone correction table.

7. The image forming apparatus according to claim **6**, wherein the correcting unit is further configured to select, when correcting the tone correction table, a different combination than the combination selected the previous time the tone correction table was corrected.

8. The image forming apparatus according to claim **1**, further comprising:

a transfer unit configured to transfer the image formed on the image carrier by the forming unit onto a recording material;

a fixing unit configured to fix, on the recording material, the image that has been transferred onto the recording material;

a reading unit configured to read the image fixed on the recording material; and

a generating unit configured to generate the reference table by causing the reading unit to read the plurality of images in the second test pattern fixed on the recording material.

9. The image forming apparatus according to claim **1**, wherein the correcting unit is further configured to interpolate the updated tone correction table by obtaining an output image data value corresponding to an input value between two adjacent input image data values among the plurality of input image data values used to form the first test pattern, based on the output image data values in the updated tone correction table corresponding to the two input image data values, the output image data values in the reference table corresponding to the two input image data values, and the output image data value in the reference table corresponding to the input value.

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